Standard and boundary layer perturbation approaches to predict nonlinear axisymmetric behavior of cylindrical shells

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Standard and boundary layer perturbation approaches to predict nonlinear axisymmetric behavior of cylindrical shells

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Abstract

The feasibility and performance of standard and boundary layer perturbation techniques in nonlinear analyses of cylindrical shells are investigated. To this end, the nonlinear axisymmetric behavior of short and long functionally graded (FG) cylindrical shells is considered. The nonlinear governing equations of shell theory with first-order approximation and the von Karman nonlinearity are decoupled. This uncoupling makes it possible to present an analytical solution. A new boundary layer perturbation solution is presented by reducing the governing equations to a normalized form of boundary-layer type. Also, the uncoupled governing equations are solved using standard one-, two-, and three-parameter expansions. Findings indicate that the boundary layer technique cannot predict the post-buckling behavior of cylindrical shells for any geometric ratios R/h and L/R, since after occurrence of instability, the behavior of shell is not boundary-layer type and it is impossible to satisfy the matching conditions. Hence, this technique is only valid for the analysis of long shells before buckling occurs. Furthermore, the standard perturbation series in terms of output parameters can predict the buckling load and the static equilibrium path with acceptable accuracy only under consideration of the deflection of points at an area near enough to the ends of the shell. On the other hand, the standard expansions in loading parameters are able to predict the snap-through post-buckling behavior accurately by considering higher-order terms (around 30th order) in expansion series.

Keywords: Functionally graded cylindrical shells; Axisymmetric behavior; Nonlinear analysis; Snap-through buckling; Analytical and perturbation solutions; Boundary layer theory

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